TITLE OF THE INVENTION

ROLL-OVER AIR BAG HAVING A REINFORCED PERIMETER SEAL AND ASSOCIATED METHOD FOR PRODUCING A FLAT REINFORCED SEAL IN A ROLL-OVER AIR BAG

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TITLE OF INVENTION

Roll-Over Air Bag Having a Reinforced Perimeter Seal and Associated Method for Producing a Flat Reinforced Seal in a Roll-Over Air Bag

CROSS-REFERENCE TO RELATED APPLICATIONS

This continuation-in-part application discloses and claims subject matter disclosed in my earlier filed pending application, Serial Number 09/110,632, which was filed on July 6, 1998.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to the field of automotive restraints. More particularly, it relates to a self-inflating restraint for protecting occupants of an automobile in the event of a vehicle roll-over.

2. Description of the Related Art

It is known in the art to protect the occupants of a vehicle with an inflated restraint commonly referred to as an airbag. The airbag is in fluid communication with an inflator, which when activated, rapidly inflates the airbag with an inflation fluid. Airbags have been in use for a number of years to protect the front occupants of a vehicle from impacting the steering wheel, dash and/or the windshield during a front impact incident. And, airbags have recently been utilized to protect the occupants striking the side of the vehicle during side-impact and/or

roll-over episodes. Those skilled in the art recognize that a major distinction between a roll-over air bag and a frontal or side impact air bag is that the frontal or side impact air bags are designed for extremely rapid deflation immediately following inflation. Contrariwise, a roll-over airbag, due to the nature of a roll-over incident, must maintain air pressure for a pre-determined amount of time in order to provide adequate protection to the vehicle occupant(s) during the roll-over episode. This sustained period of inflation under pressure requires a reinforced perimeter not found on typical frontal or side impact airbags. It will be appreciated that roll-over airbags, often referred to as "curtains", are typically stored, either in the seat, in the side pillar, or proximate the conjunction of the headliner and the side panel of the vehicle in a deflated, and often folded, condition. For example, U.S. Patent No. 5,529,332 issued to Wipasuramonton on June 25, 1996, and U.S. Patent No. 5,540,460 issued to Wipasuramonton on July 30, 1996, each disclose a side-impact airbag which is inflatable into a position between a vehicle occupant and the side structure of a vehicle.

U.S. Patent No. 5,909,895, issued to Iino, et al. discloses a thermoplastic resin film bag. The background art section describes a conventional airbag having a reinforced joint face and teaches that the reinforcing cloth is a cylindrical body that is three-dimensionally arranged to a two dimensional join face in which production is troublesome and in which, if joined two-dimensionally, creates a problem with wrinkling the joint face.

What has heretofore been missing from the art is a roll-over self-inflating airbag that has a reinforced perimeter seal that is capable of sustaining the requisite pressure of the airbag for a predetermined period of time, and that is configured to limit the displacement of the sides from one another during expansion. What has also been missing from the art is a method of producing a reinforced joint, or seam, that can be sealed flat, without a problem of wrinkling the joint face, while still providing adequate reinforcement of the sealed edge.

Accordingly, it is an object of the present invention to provide a roll-over airbag that has perimetrically reinforced sealed edges.

Another object of the present invention is to provide a roll-over airbag that is configured so as to limit the displacement of the sides from one another during expansion of the airbag.

Still another object of the present invention is to provide a roll-over airbag that has a series of internal, reinforced tethers for limiting the displacement of the sides from one another during expansion of the airbag.

A further object is to provide a method for providing a sealed flat reinforcing lap joint along the sealed edges.

Other objects and advantages over the prior art will become apparent to those skilled in the art upon reading the detailed description together with the drawings as described as follows.

BRIEF SUMMARY OF THE INVENTION

In accordance with the various features of this invention, a roll-over airbag is provided. The roll-over airbag of the present invention is defined by an inflatable air bag constructed of an upper fabric panel having a perimeter of a pre-selected length and a lower fabric panel perimetrically bonded to the upper fabric panel. In the preferred embodiment, this joint is reinforced with a lap joint so as to distribute the stress of rapid inflation over a larger surface area of the fabric and thereby transform an otherwise tear stress into a shear stress. In the preferred embodiment, the fabric material is a woven nylon, or other supported fabric, in which the interior has been treated with a urethane coating or other thermoplastic material that is reactive to high frequency energy, in order to be impermeable to the inflation fluid. During manufacturing, the lap joint and the perimetric edges are sealed flat by means of radio frequency (RF) bonding. At least one port opening is provided in the upper fabric panel for connecting the roll-over bag to an inflator to allow communication of the expansion fluid from the inflator to the roll-over airbag. Further, in accordance with the present invention, the process of bonding the lap joint prevents the lap joint from bonding to itself. In this regard, the lap joint is variously constructed of a material that prevents the bonding agent from bleeding through, constructed of a material having an impermeable agent adhered thereto, or has a template sandwiched between the upper and lower portions of the lap joint during the sealing process.

In addition to having perimeter reinforced inner seals, the roll-over airbag is constructed so as to limit the displacement of the upper

and lower fabric panels from one another during inflation. In one embodiment, this is accomplished with at least one tether disposed within the airbag. Alternatively, the shape of the airbag and its perimetric contours can be selected for limiting displacement of the upper and lower fabric panels from one another. With the former, the tether has a first end bonded to the upper fabric panel and a second end bonded to the lower fabric panel. The length of the tether is preselected in order to determine the thickness and/or height of the expanded roll-over airbag. It will be appreciated by those skilled in the art that, in limited applications, it may be necessary to accommodate passage of a seat belt through the roll-over airbag, in such instances a passageway, having an expandable through opening, is disposed in the roll-over airbag.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The above-mentioned features of the invention will become more clearly understood from the following detailed description of the invention read together with the drawings in which:

Fig. 1 illustrates a top plan view of the roll-over airbag of the present invention.

Fig. 2 illustrates a partial cross-sectional view of the roll-over airbag taken at lines 2 — 2 in Figure 1.

Fig. 3 illustrates a partial cross-sectional view of the roll-over airbag taken at lines 3 — 3 in Figure 1.

Fig. 4 illustrates a partial cross-sectional view of the roll-over airbag taken at lines 4 — 4 in Figure 1.

Fig. 5 illustrates a partial cross-sectional view of an alternate embodiment of the tether utilized in the present invention.

Fig. 6 illustrates a perspective view of the tether illustrated in Fig. 4.

Fig. 7 illustrates a perspective view of the tether illustrated in Fig. 5.

Fig. 8 illustrates a partial schematic view of the placement locations of the roll-over airbag of the present invention.

Figs. 9a-c illustrate top plan views of further alternate embodiments of the tether utilized in the present invention, in which the tethers are low profile tethers.

Fig. 10 illustrates a cross-sectional view of the tether illustrated in Fig. 9a, taken along line 10 – 10 in Fig. 9a.

Fig. 11 illustrates a partial cross-sectional view of the tether illustrated in Fig. 9a, installed in an alternate embodiment roll-over airbag.

Fig. 12 is a top plan view of the roll-over airbag shown in Fig. 11.

Fig. 13 illustrates a schematic view, not drawn to scale, of the process of RF bonding a flat lap-joint reinforced seam.

Fig. 14 illustrates a top plan view of a preferred method of forming an internal radius lap joint.

Fig. 15 illustrates a partial top plan view, showing the bottom panel of the roll-over airbag, of a preferred method of forming an external radius lap joint.

Fig. 16 illustrates a partial top plan view, showing the bottom panel of the roll-over airbag, of a notched portion of the reinforcing member for forming an internal or external radius.

Fig. 17 illustrates a top plan view of a further alternate embodiment roll-over airbag having a reinforced perimeter seal.

Fig. 18 illustrates top plan view of a still further alternate embodiment roll-over airbag having a reinforced perimeter seal.

DETAILED DESCRIPTION OF THE INVENTION

A roll-over airbag, constructed in accordance with the present invention, is illustrated generally as **10** in the figures. The roll-over airbag **10** is defined by an inflatable airbag **12** constructed of an upper fabric panel **15** having a perimeter **18** of a pre-selected length and a lower fabric panel **20** perimetrically bonded to the upper fabric panel **15**. It should be understood that reference to upper and lower panels is simply for clarity of description and is not intended to limit the spatial orientation of the roll-over airbag **10**. In the preferred embodiment, both the upper and lower fabric panels **15** and **20**, respectively, are a woven nylon, or other supported fabric, in which the interior has been treated, often with a urethane coating, or coating of a similar thermoplastic that is reactive to high frequency, or radio frequency (RF), energy, in order to be impermeable to the inflation fluid. However, other materials could be utilized so long as the result is an

inflation fluid impermeable material. At least one port opening **25** is provided in the upper fabric panel **15** for connecting the roll-over bag **10** to an inflator (not shown) to allow communication of the expansion fluid (not shown) from the inflator to the roll-over airbag **10**.

As mentioned above, the perimeter edges **18** and **22**, respectively, of the upper and lower fabric panels **15** and **20** are bonded together. In the preferred embodiment, the upper and lower fabric panels **15** and **20** are secured, preferably, by a RF weld or alternatively, an ultrasonic or thermal weld. Thus, it will be appreciated that the coating agent is preferably reactive to RF energy in order to effect bonding. However, the upper and lower fabric panels **15** and **20** can also be secured by means of an adhesive which has a high degree of thermal stability. It will be recognized by those skilled in the art that the time for inflating and thus, expanding roll-over airbag **10** is measured in milliseconds, and that, as a result, a large amount of tear stress is placed upon the state of the art joint, or seal. Moreover, a roll-over airbag must sustain this pressure for a longer period of time than the state of the art frontal or side impact airbag, which, by design, deflates rapidly immediately following inflation. In order to reinforce this joint, a lap joint **30** is utilized using an additional piece of fabric in order to distribute the stress over a larger surface area of the upper and lower fabric panels **15** and **20** and thereby transform the tear stress into a shear stress. In this regard, at least one securement member **32** is disposed proximate the perimeter seal such that the upper portion **34** of the securement member **32** is bonded to the upper fabric panel **15** and the lower portion **36** of the securement member **32** is bonded to the

lower fabric panel **20**. Tests have shown that this reinforced perimeter seal is capable of sustaining pressure for an extended period of time. Figure 16 illustrates a segment **132** that is notched so as to form either an internal radius, illustrated in Fig. 14, or an external radius, illustrated in Fig. 15. In either configuration, if additional reinforcement is necessary, an additional curved segment (not shown) can be bonded over the portion of the segment **132** that is bonded to the upper fabric panel **15** and an additional curved segment (not shown), can be bonded over the portion of the segment **132** is bonded to the lower fabric panel **20**.

It is often desirable to limit the height and/or thickness of the roll-over airbag **10** by limiting the displacement of the upper and lower fabric panels **15** and **20** from one another during expansion of the roll-over airbag **10**. This can be accomplished by specifically configuring the shape of the airbag as illustrated in Figure 17 in which airbag **210** is specifically configured so as to limit the displacement of the upper and lower fabric panels **15** and **20** from one another. Similarly, Figure 18 illustrates a further alternate embodiment in which airbag **310** is folded along one edge **320** and which includes a centrally located region **330** that is not inflated. This effect can also be achieved by disposing at least one tether member **40** within roll-over airbag **10** for limiting displacement of the upper and lower fabric panels **15** and **20** from one another. In this regard, the tether **40** has a first end **45** bonded to the upper fabric panel **15**, a center panel **50**, and a second end **55** bonded to the lower fabric panel **20**. It will be appreciated by those skilled in the art that the height of the central panel **50** is selected

in order to select the height of the airbag **10**. Additional factors that determine the ultimate height of the airbag **10** are the number of tethers **40** disposed within airbag **10** and the distance between the tethers **40**. As shown in Figures 4 and 6, the ends **45** and **55** of the tether **40** can be bonded to a substrate **60** which is in turn bonded to the upper or lower fabric panel **15** or **20** in order to reduce the risk of rupture and to strengthen the bond between the tether **40** and the upper and lower fabric panels **15** and **20**. As seen in Fig. 4, the tether **40**, in the preferred embodiment is at least a two ply fabric member and has a substantially I-shaped cross-section. Further, to distribute the stress of expansion over a larger surface area of the ends **45** and **55** of the tether **40**, the edges **62** and **64** of the center panel **50** have a substantially concave configuration.

In Figs. 5 and 7, an alternate embodiment of a tether is illustrated as tether **40'**. In this regard, tether **40'** is defined by ~~defined by~~ a first folded fabric member **70** which is bonded to the upper fabric panel **15** and a cooperating second folded fabric member **75**. The folded portions of first folded fabric member **70** and second folded fabric member **75** are secured to one another by a securement member **80**, which in the preferred embodiment is defined by parallel rows of stitching. Further, to distribute the stress of expansion over a larger surface area, the terminal ends of securement member **80**, are not coextensive with the edges of the first and second folded fabric members **70** and **75**. In this regard, first and second folded fabric members **70** and **75** have a first preselected width and securement

member **80** has a second preselected width which is less than the preselected width of first and second folded fabric members **70** and **75**.

A further alternate embodiment tether is illustrated in Figures 9-12. Tether **40"** is a low-profile tether. In this regard, the tether **40"** is defined by an upper panel member **140** secured to a lower panel member **145**. The upper and lower panels **140** and **145** are secured to one another by means of at least one region of securement **160**. In one embodiment, illustrated in Figure 9a, region of securement **160** is defined by one row, and preferably at least two parallel rows, of stitching **150**.

If additional securement of the upper panel member **140** to the lower panel member **145** is desired, for instance, in order to distribute stress at the end of each row of stitching **155** over a broader surface area, the terminal ends can be joined by means of an additional region of securement **165** which is wider than the region of securement **160**. In one embodiment, the additional region of securement **165** is defined by a row of stitching **155**, which encloses an area having a greater width than the width of the rows of stitching **155**, and which is preferably circular or elliptical.

It will be appreciated by those skilled in the art that other means of bonding could be utilized to secure the upper and lower panels **140** and **145** in tether **40"**, for instance rather than stitching, as described above, the upper and lower panels **140** and **145** could be bonded to one another by an RF weld as described above with regard to the perimetric seal. In another embodiment, illustrated in Figure 9c, region of securement **160** is defined by a substantially circular region of

securement **160'**. In this embodiment, it is preferable to include at least two circular regions of securement **160'** in spaced relation.

In either embodiment of tether **40"**, the upper panel member **140** of the tether **40"** is then bonded to the upper fabric panel **15** or **15'** of either roll-over airbag **10** or **10'**, respectively, while the lower panel member **150** of the tether **40"** is secured to the lower fabric panel **20** or **20"** of either airbag **10** or **10'**, respectively. While preferred methods of providing the region of securement **160**, have been described, those skilled in the art will recognize that other methods are feasible. In this regard, there are multiple stitching patterns that could be utilized to provide at least one region of securement **160**, and at least one region of securement **160** could be provided by having the upper and lower panels **140** and **145** woven together at selected areas.

Those skilled in the art will appreciate that as illustrated in Fig. 8, there are numerous places in vehicle **105** that roll-over airbag **10** can be stored. For instance, roll-over airbag **10** can be stored in the seat back at **110**, in the side pillar at **115** or proximate the headliner at **120**. Those skilled in the art will recognize that in certain applications, it is desirable to store roll-over airbag **10** at **110** in a manner that permits a seatbelt, (not shown), to pass through the roll-over airbag **10** while folded. In these circumstances where it is desirable to provide for passage of a seat belt through the roll-over airbag **10**, a passageway **85** is disposed in the roll-over airbag **10**. In this regard, a first opening **87** is provided in the upper fabric panel **15** and a second opening **89** is provided in the lower panel **20** with the first opening **87** and the second opening **89** being in register. In order to maintain the impermeability

of the roll-over airbag, a channel member **90** is provided that registers with the first opening **87** and the second opening **89**. The channel member **90** has an upper end **92** bonded to the upper fabric panel **15** and a lower end **94** bonded to the lower fabric panel **20**, thus providing a through-opening in the roll-over airbag **10**. In order to allow the roll-over air bag **10** to expand uniformly in the proximity of the passageway **85**, the channel member **90** is expandable. In this regard, expansion of the channel member **90** is accomplished by providing at least one pleat **96** in the channel member **90**. The pleats **96** allow the channel member **90** to fold flat when the roll-over airbag **10** is deflated and allows substantially uniform expansion of the roll-over airbag **10** during inflation.

As mentioned above, the upper and lower fabric panels **15** and **20** are secured to one another, and the securement member **32** is secured thereto in the manner described above preferably by RF bonding. Referring to Fig. 13, it will be appreciated that a RF bonding machine **170** typically includes a RF generator **175**, and RF energy conducting electrodes defining a top plate **180** and a bottom plate **185**. In order to bond a flat seam, the securement member **32** is positioned between the upper and lower fabric panels **15** and **20**. A metal form **190** is placed directly above the securement member **32** and between the upper fabric panel **15** and the top plate **180**. In this manner, a flat seam is pressed between the metal form **190** and the bottom plate **185**. The metal form **190** has a surface area selected to conform to the region to be bonded. The metal form is also in direct communication with either the top plate **180** or the bottom plate **185** and serves to

provide a path of least resistance that concentrates the RF energy on the region to be bonded. It will be appreciated that the perimeter edge of the airbag can be bonded prior to positioning the securement member **32** or the securement member **32** can be positioned with respect to the upper and lower fabric panels **15** and **20**, and the perimetric edge and the lap joint bonded sequentially or simultaneously. It will be appreciated that metal form **190** can be a selected metal bar having a geometric surface area that conforms to the surface area of a region to be bonded and the joints are bonded sequentially, or metal form **190** could be a template (not shown) machined to bond all of the joints simultaneously.

In order to prevent the upper and lower portions of the securement member **32** from bonding to each other, a template barrier **195**, that is not reactive to RF energy, is disposed between the upper and lower portions of the securement member **32**. The template barrier **195** is repositioned as each section is bonded and is removed through an opening, such as inflator port **25**. Alternatively, the template barrier **195** can be left in the sealed airbag. As an alternative method, the securement member **32** can be formed from a material that prevents the bonding agent from bleeding through the fabric, or can be coated on the non-bonded side with a thin film barrier such as Mylar. It will be appreciated by those skilled in the art that this method is useful for sealing each of the reinforced joints discussed herein. The foregoing method allows the reinforced joint to be sealed in a flat configuration in a manner that prevents wrinkling of the joint face.

From the foregoing description, it will be recognized by those skilled in the art that a roll-over airbag offering advantages over the prior art has been provided. Specifically, the roll-over airbag of the present invention provides a roll-over airbag that has perimetrically sealed edges that are reinforced with a sealed lap joint that renders the perimetrically sealed edges capable of sustaining pressure for an extended period of time. Further, the present invention provides a roll-over airbag that is either configured so as to limit the displacement of the sides from one another during expansion of the airbag or includes at least one internal, reinforced tether for limiting the displacement of the sides from one another during expansion of the airbag. The present invention further provides a novel method for providing a sealed flat reinforcing lap joint along the sealed edges.

While a preferred embodiment has been shown and described, it will be understood that it is not intended to limit the disclosure, but rather it is intended to cover all modifications and alternate methods falling within the spirit and the scope of the invention as defined in the appended claims.